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Ulan-Ude
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Regular Session
INLAND LAKES IN A CHANGING WORLD: ANTHROPOGENIC AND CLIMATE CHANGE EFFECTS ON SALINITY, ECOLOGY AND BIOGEOCHEMICAL CYCLING
Chairs: Erik Jeppesen, Naser Agh

The past and future of the biological resources of the Caspian and the Aral Seas

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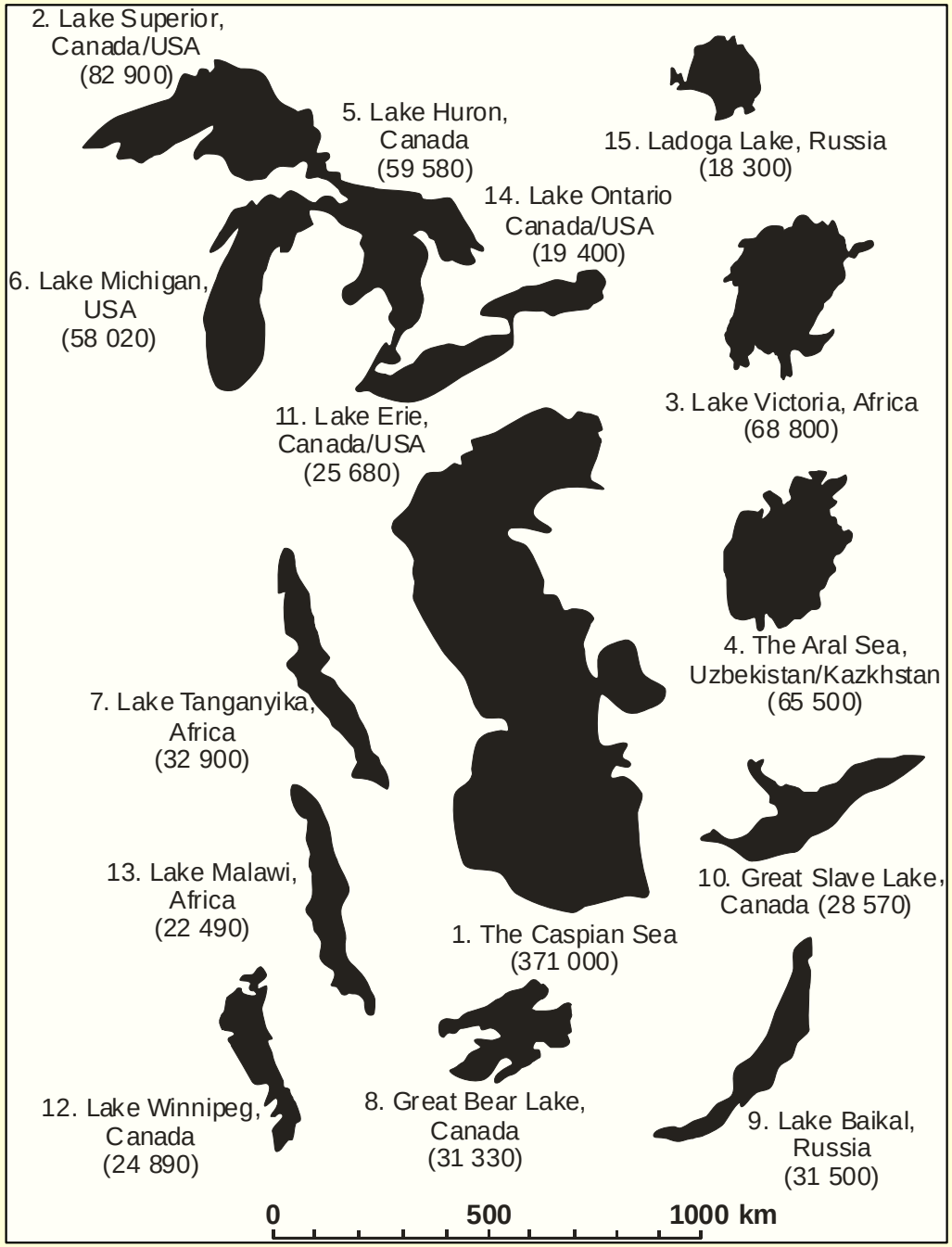
Caspian Sea is the world's largest lake

(area of the world's largest lakes is shown in brackets in km²; area of the Aral Sea is given for 1960)



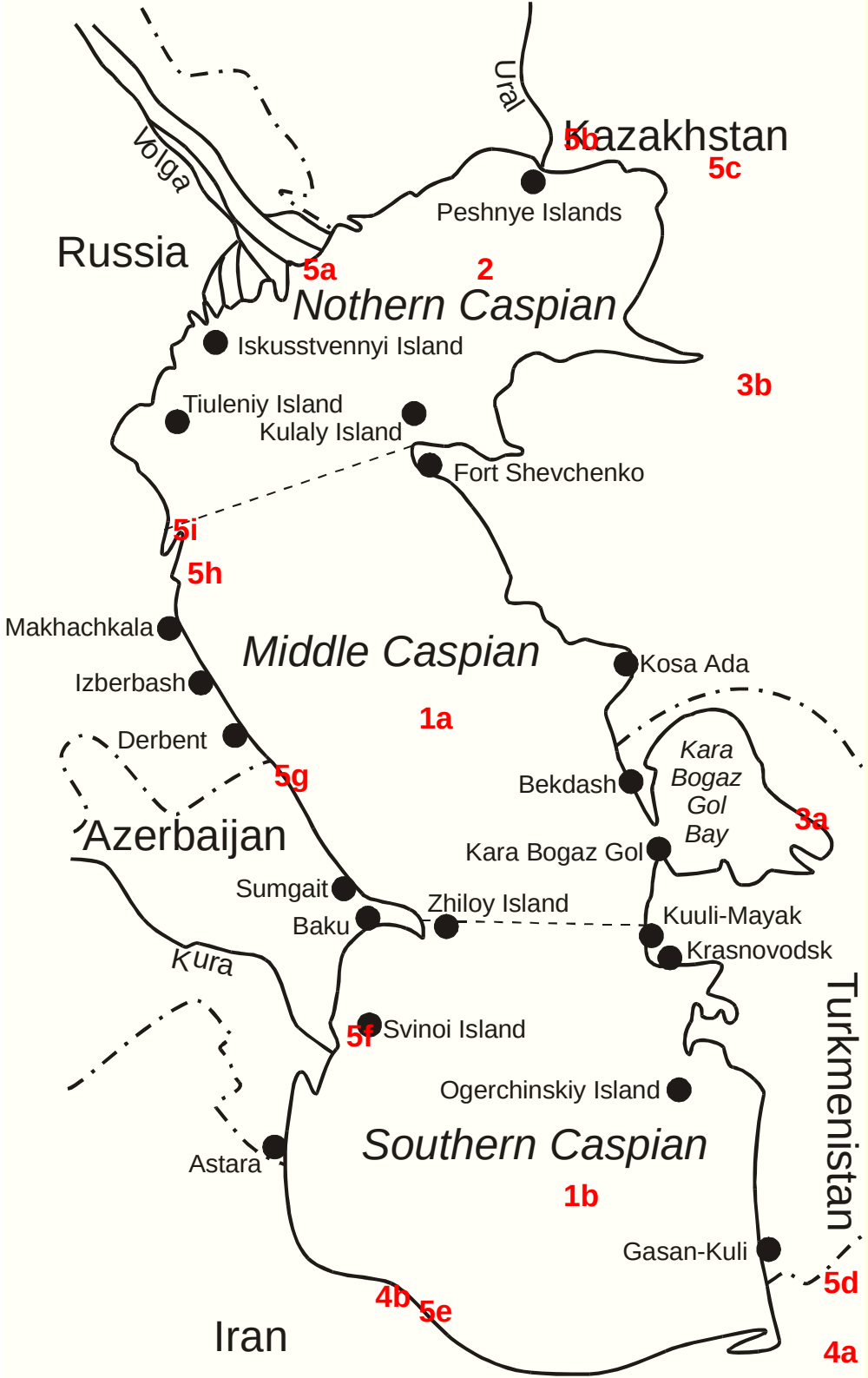
Main parameters of the Caspian Sea

The Caspian Sea	
Max. length	1204 km
Max. width	566 km
Mean width	204 km
Volume	77000 km^3
Max. depth	1025 m
Mean depth	184 m
Area	436000 km^2

The Middle Caspian Sea	
Volume	35.39%
Area	36.63%
Max. depth	770 m
Mean depth	175.5 m

The Northern Caspian Sea	
Volume	0.94%
Area	27.73%
Max. depth	10 m
Mean depth	6.2 m

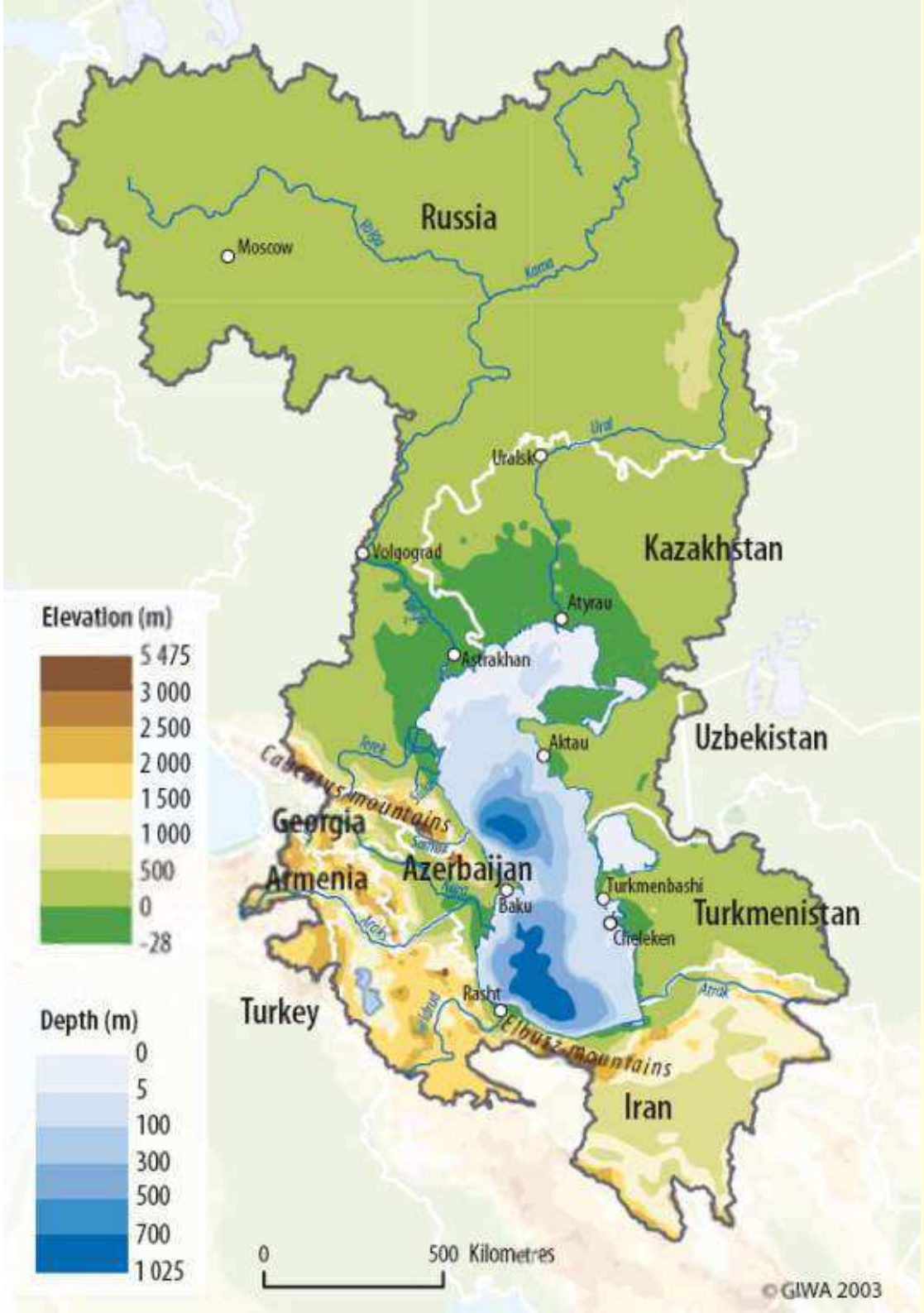
The Southern Caspian Sea	
Volume	63.67%
Area	35.64%
Max. depth	1025 m
Mean depth	325 m



Caspian Sea zones

(by Aladin, Plotnikov, 2000)

1. **Middle (1a) and Southern (1b) Caspian Seas = the Caspian Sea proper.**
2. **Northern Caspian (2) – a giant shallow bay, estuary of 4 rivers: Volga, Ural, Terek, Sulak.**
3. **Hyperhaline bays on the Eastern coast: Kara-Bogaz Gol (3a), Mertvy Kultuk (3b).**
4. **Low saline bay and lagoon on the Southern coast: Gorgan Bay (4a), Anzaly Lagoon (4b).**
5. **Low saline estuaries and deltas of Caspian Sea rivers: Volga (5a), Ural (5b), Emba (5c) (not inflowing now), Atrek (5d), Sefidrud (5e), Kura (5f), Samur (5g), Sulak (5h), Terek (5i).**



Catchment area of the Caspian Sea.

Dark-green area is below the present Ocean level.

Number of species in the Caspian Sea

Derzhavin (1951) & Zenkevich (1963)	476
Chesunov (1978)	~ 550
Kasymov (1987)	~ 950
Dumont (1998)	~ 1800
Aladin et al. (2001)	> 2000

Caspian Sea endemic animals

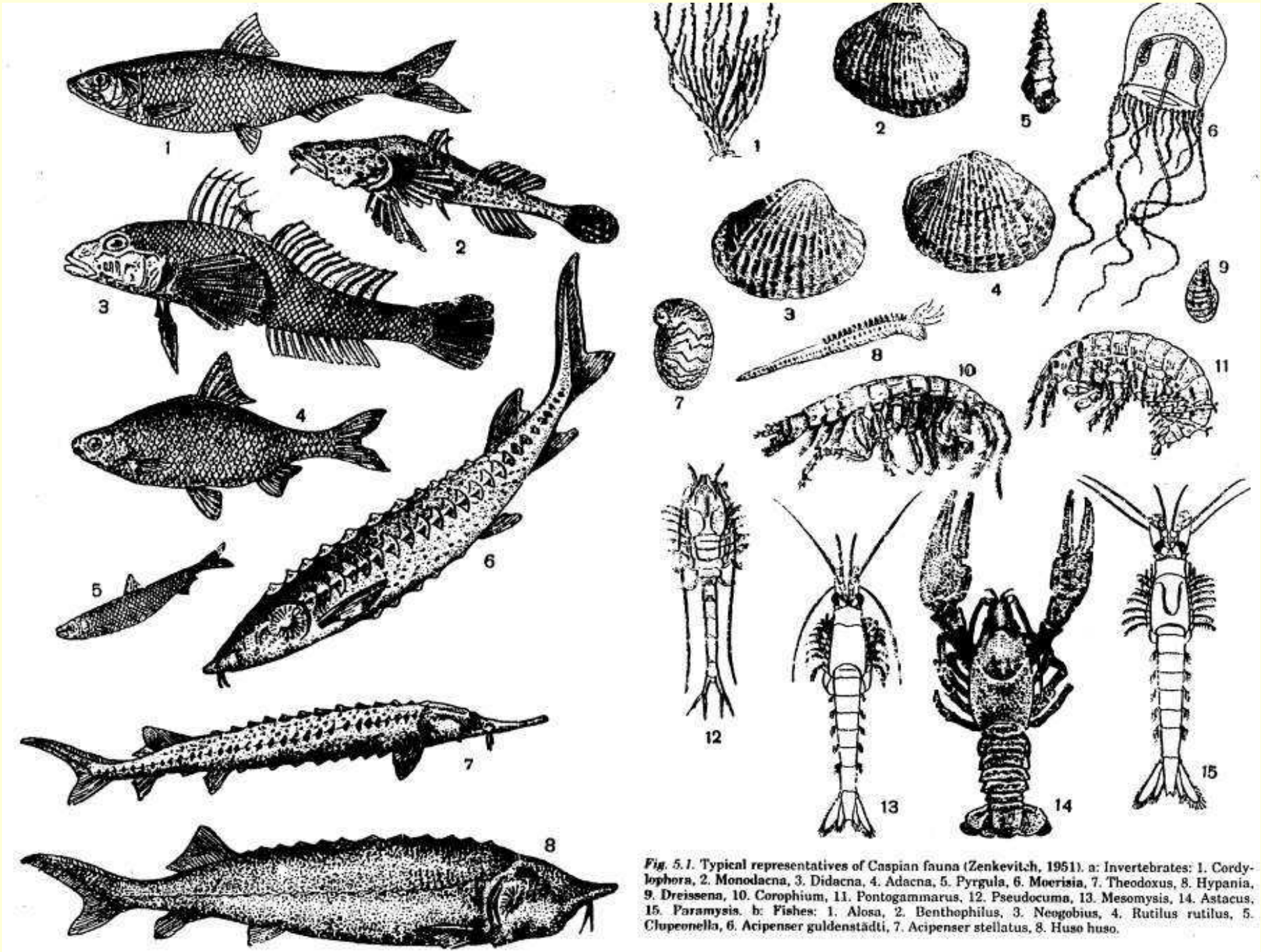
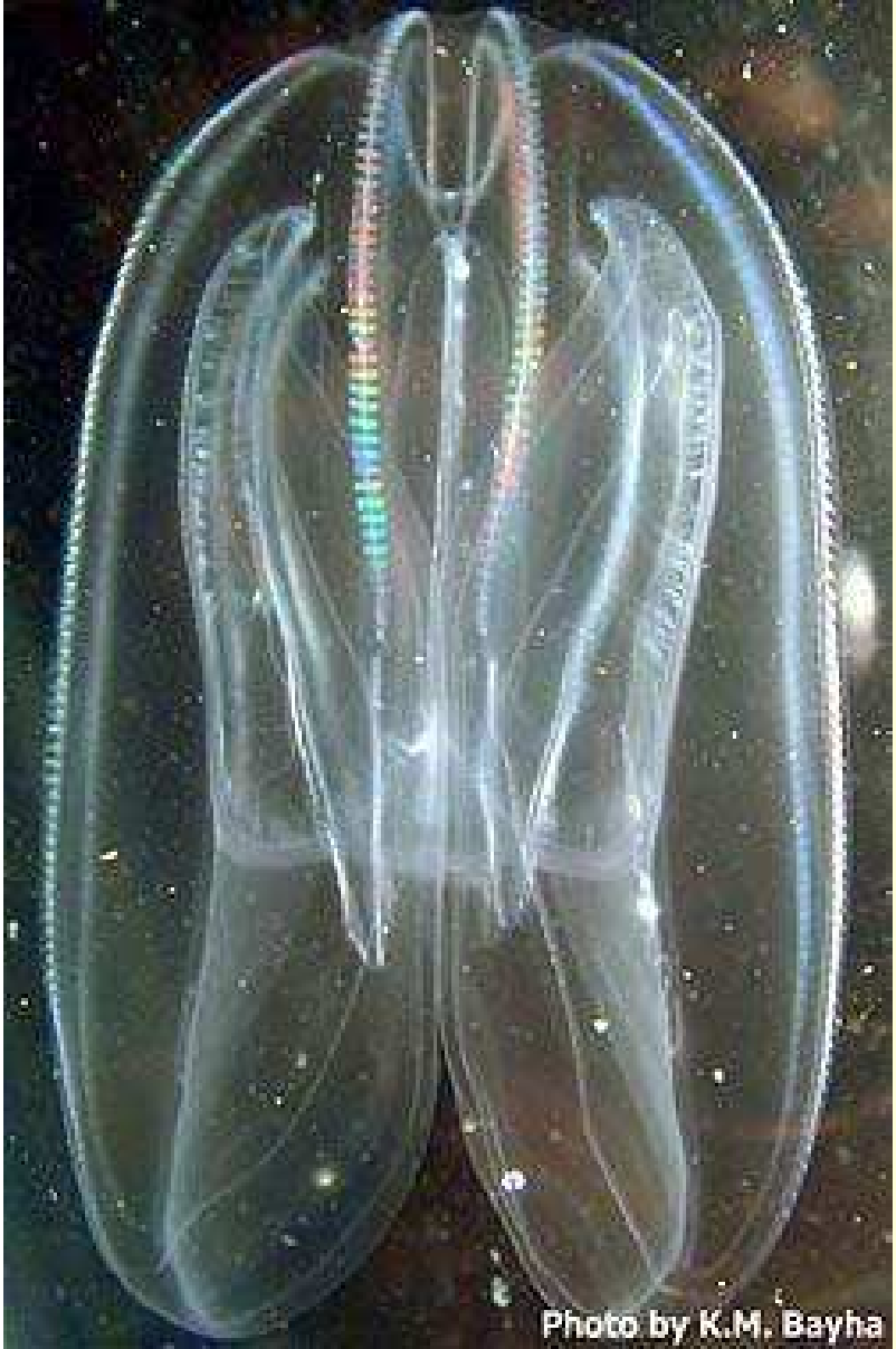


Fig. 5.1. Typical representatives of Caspian fauna (Zenkevitch, 1951). a: Invertebrates: 1. Cordylophora, 2. Monodacna, 3. Didacna, 4. Adacna, 5. Pyrgula, 6. Moerisia, 7. Theodoxus, 8. Hypania, 9. Dreissena, 10. Corophium, 11. Pontogammarus, 12. Pseudocuma, 13. Mesomysis, 14. Astacus, 15. Paramysis. b: Fishes: 1. Alosa, 2. Benthophilus, 3. Neogobius, 4. Rutilus rutilus, 5. Clupeonella, 6. Acipenser guldenstädti, 7. Acipenser stellatus, 8. Huso huso.

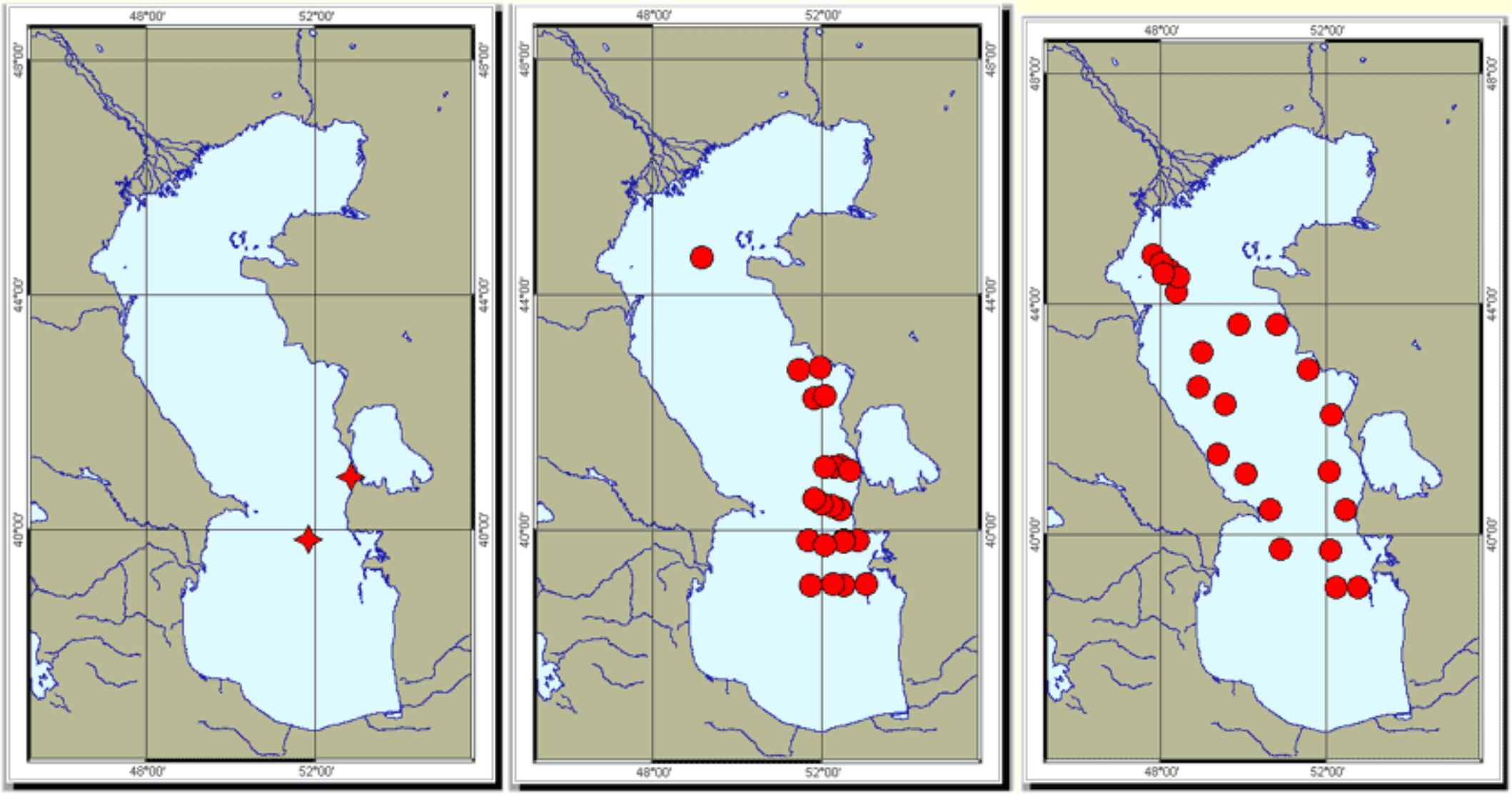


Mnemiopsis leidyi

The native habitat of the ctenophore *Mnemiopsis leidyi* is in temperate to subtropical estuaries along the Atlantic coast of North and South America, where it is found in an extremely wide range of environmental conditions.

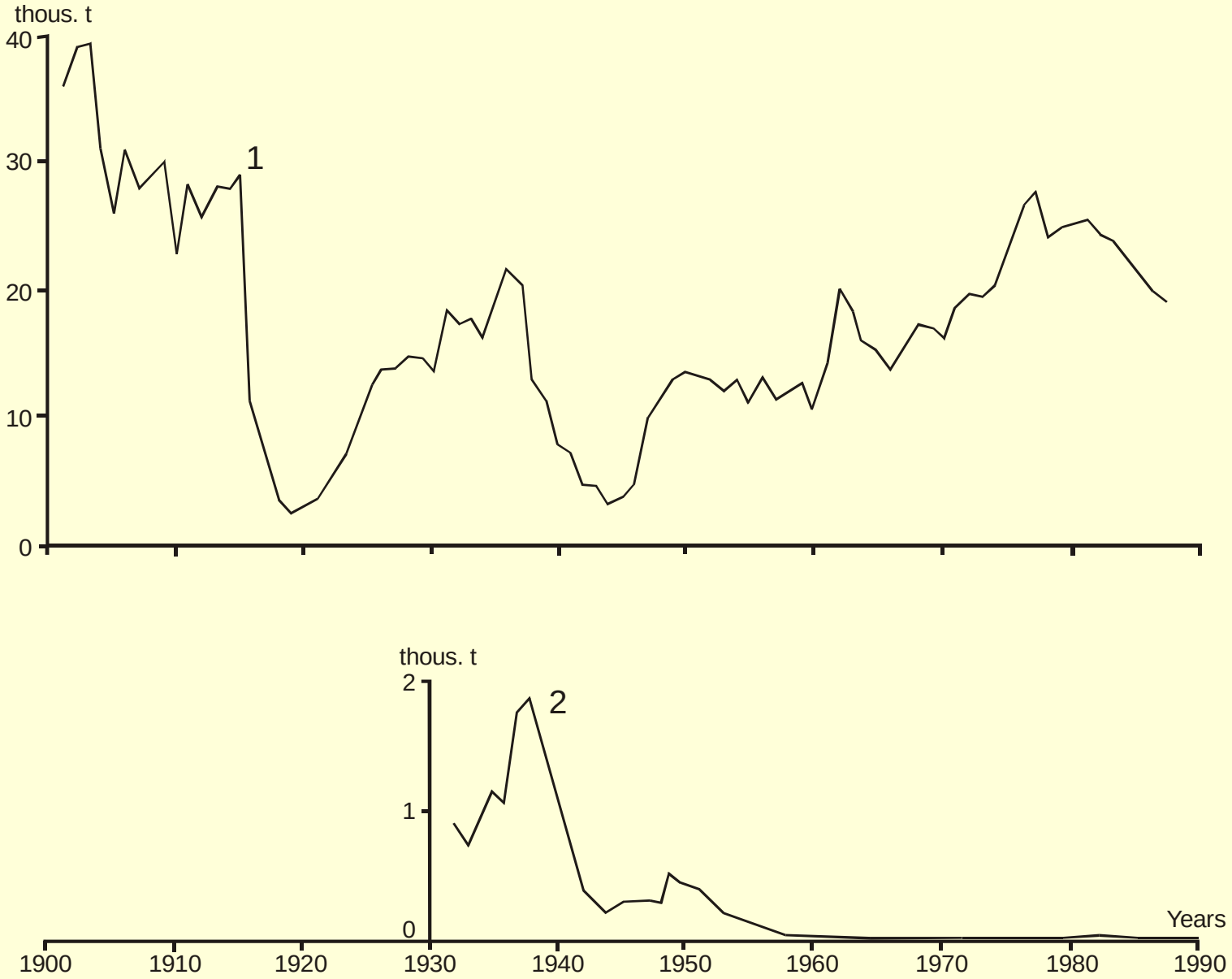
Winter low and summer high temperatures of 2ºC and 32ºC, respectively, and salinities of < 2 to 39 g/l.

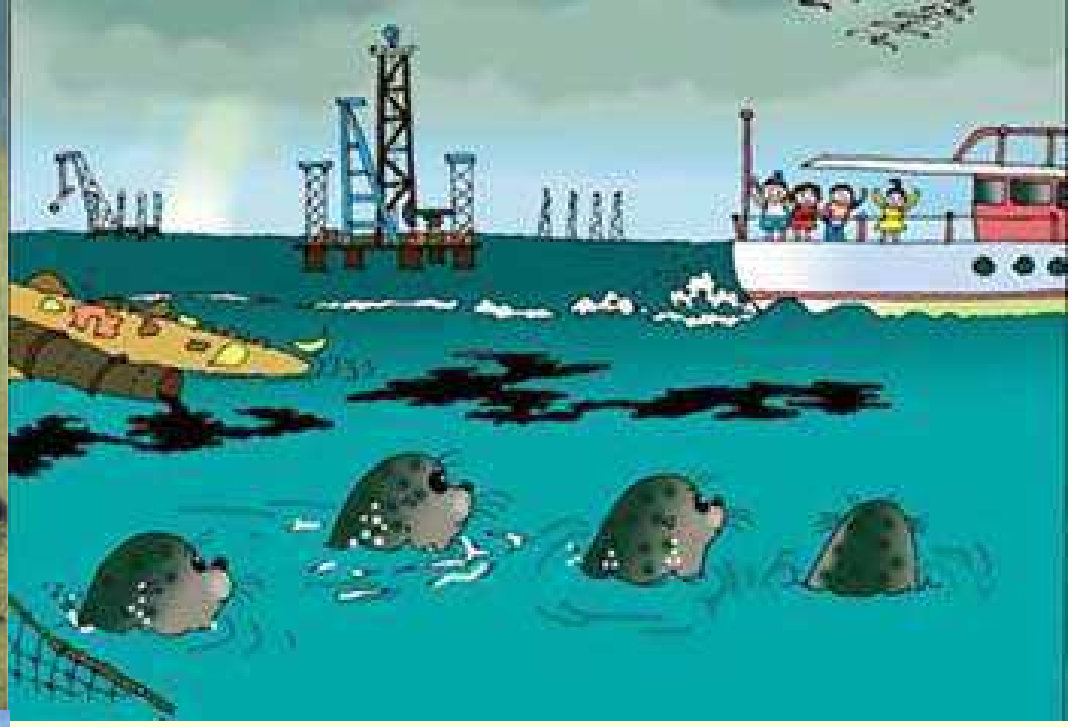
Mnemiopsis spreading over Caspian Sea



1999 2000 2001

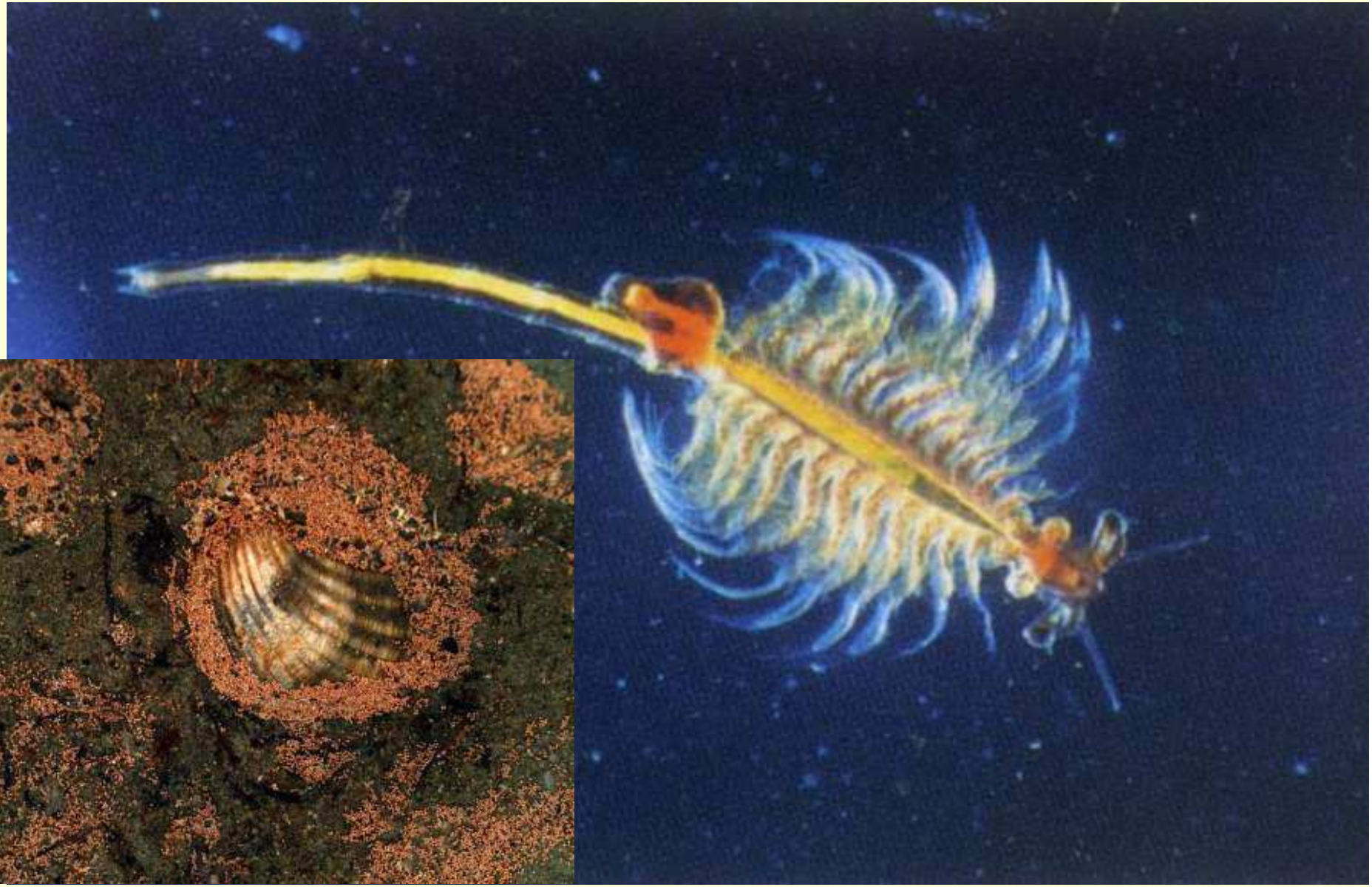
Dynamics of sturgeon catches (1) and salmons (2) in the Caspian Sea, thousands of tons





1.At the end of XX century about 25% of Caspian seal population died out due to various diseases.
2. Very warm winter of 2000 and lack of solid ice in the Northern Caspian Sea created big problems for seal reproduction.
3. Some scientist believed that it was walrus in the Caspian Sea, but in Medieval time hunters totally exterminated this giant aquatic mammal

Artemia and its cysts



Floating cysts of *Artemia*

Studying and testing *Artemia* cysts in laboratory (Akatau, Kazakhstan)


On the demonstrated photo president of Kazakhstan participated in the opening ceremony for Mangistau Bioresource

Famous “Caspian Sea monster”

In order to have successful navigation in the shallowing Caspian Sea special military boats were built

Main threats to the Caspian Sea biological resources

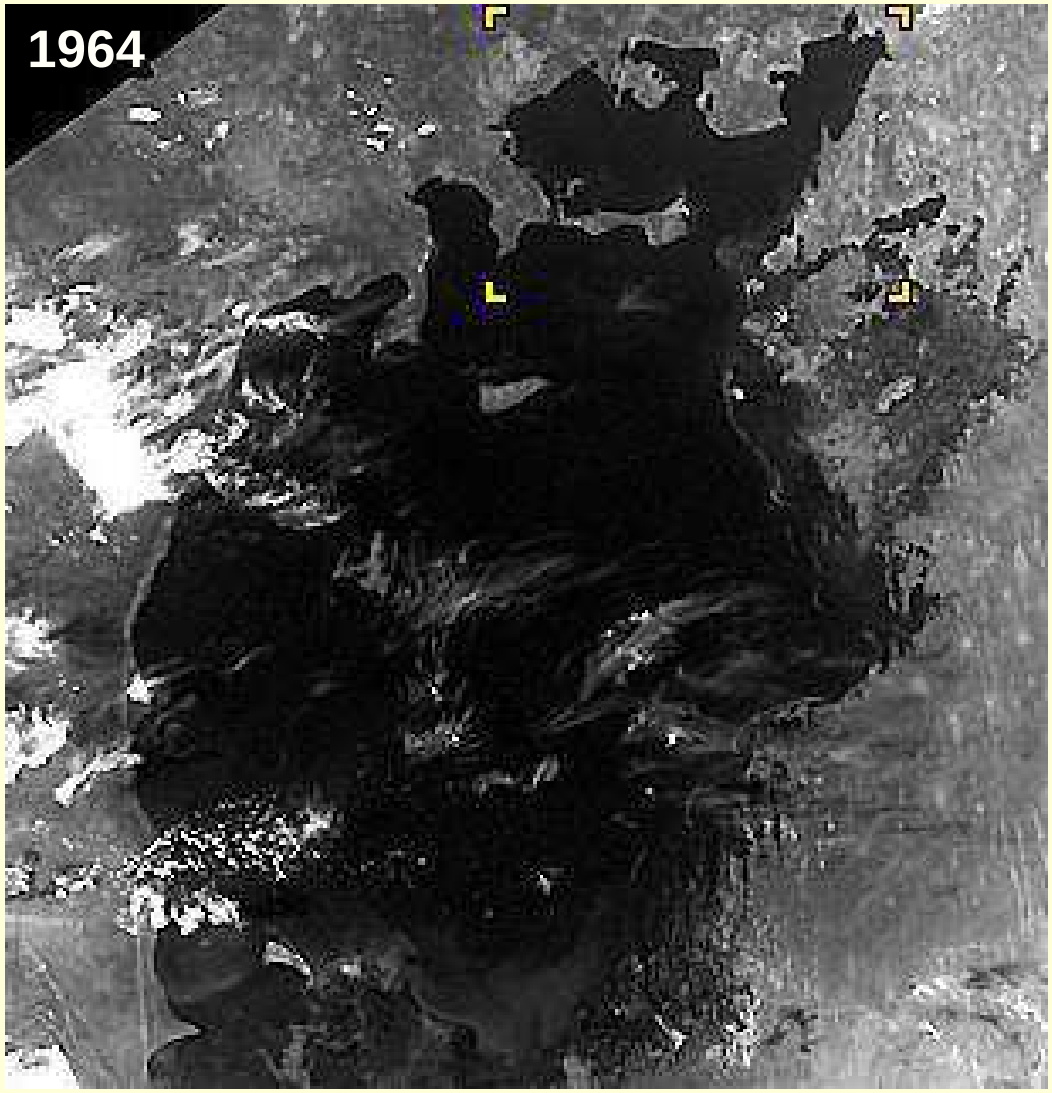
1. Pollution due to:
   oil and gas excavation and transportation,
   agricultural activities,
   industrial activities,
   military activities
2. Exotic species introduction
3. Overfishing and pouching
4. Rivers regulation
5. Sea level fluctuation
6. Climate change

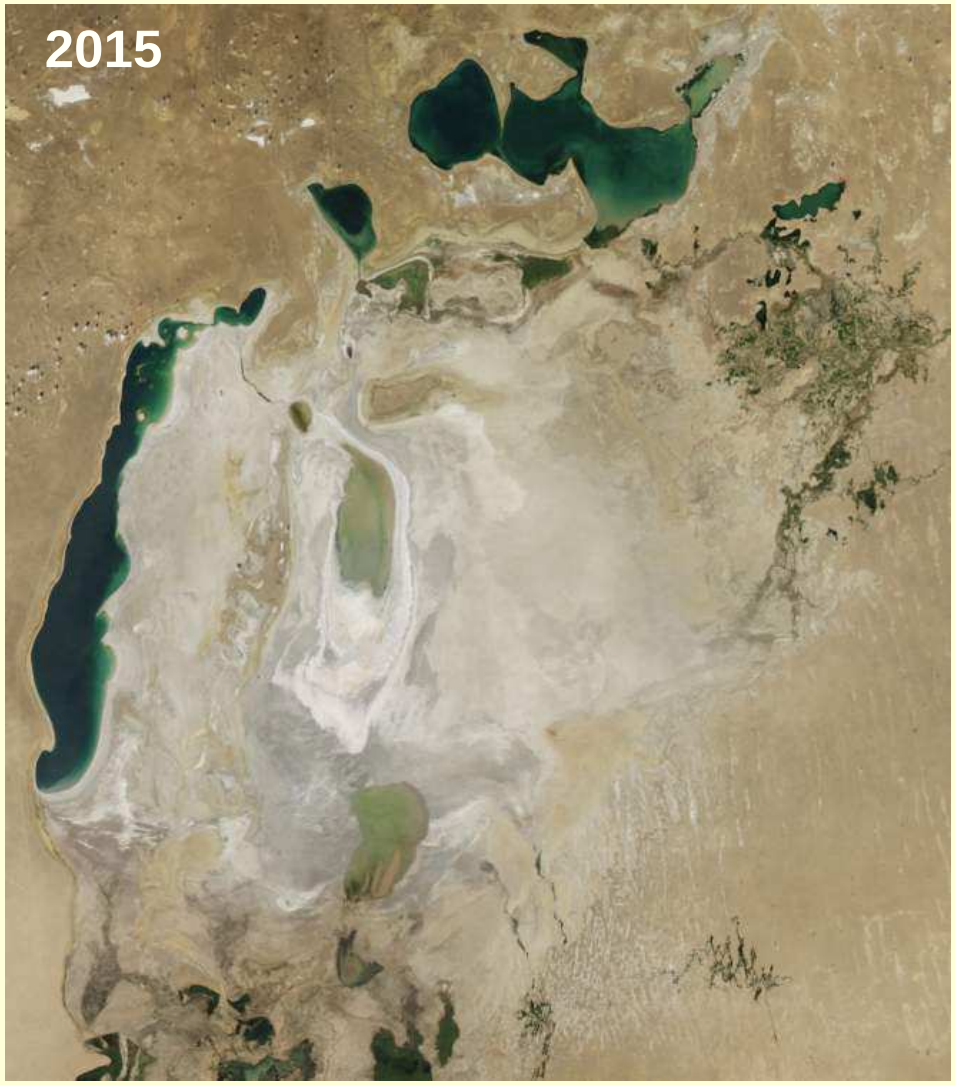

Commonwealth of Independent States - Central Asian States
RUSSIA
KAZAKHSTAN
MONGOLIA
CHINA
KYRGYZSTAN
TAJIKISTAN
UZBEKISTAN
TURKMENISTAN
AZERBAIJAN
IRAN
AFGHANISTAN
PAKISTAN
INDIA
Catchment area of the Aral Sea is about 1.8 million km²
ARAL SEA BASIN
Aral Sea
Caspian Sea
Lake Balkhash
Volga-Don Canal
Scale 1:16,500,000
Lambert Conformal Conic Projection, standard parallels 47°N and 62°N
300 Kilometers
300 Miles
Boundary representation is not necessarily authoritative.
802384 (R00030) 5-95

Parameters of the Aral Sea in the beginning of 20th century

- Area 67499 km^2
  Large Aral 61381 km^2
  Small Aral 6118 km^2
- Volume 1089 km^3
  Large Aral 1007 km^3
  Small Aral 82 km^3
- Level +53.4 m
- Maximal depth 69 m
- Salinity about 10 g/l
- The Aral Sea was inhabited by about 20 species of fishes and about 200 species of free-living invertebrates

Since 1960 the Aral Sea has steadily shrunk and shallowed owing overwhelmingly to irrigation withdrawals from its influent rivers (Amu Dar'ya and Syr Dar'ya)





August, 2015: Aral area – 8031 km^2 (12%), volume – 48 km^3 (4.5%);
the Large Aral – 3900 km^2 (6%), 58 km^3 (5.5%), salinity >100 g/l;
the Small Aral – 3300 km^2 (57%), 27 km^3 (33%), salinity 6-7 g/l.

IRRIGATION DEVELOPMENT IN ARAL SEA BASIN

MAJOR IRRIGATION COMPLEXES IN THE ARAL SEA BASIN

main irrigation zones in the Aral Sea Basin

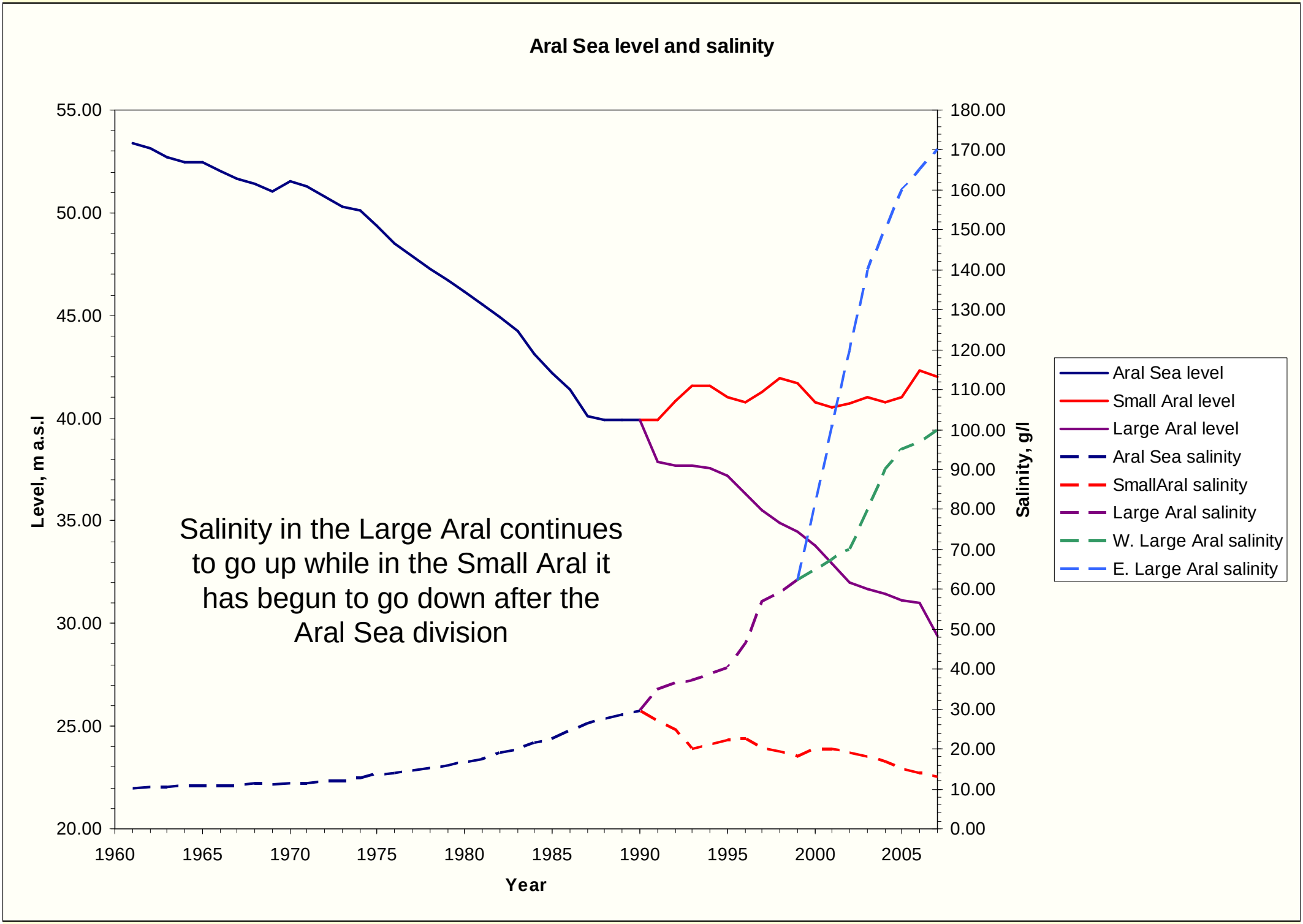
proposed Siberia-Aral Sea Canal

1. Kara-Kum Canal
2. Amu Dar'ya Delta
3. Amu-Bukhara Canal
4. Zeravshan Valley
5. Karshi Steppe
6. Middle Amu Dar'ya
7. Surkhandar'ya Valley
8. Golodnaya Steppe
9. Fergana Valley
10. Middle Syr Dar'ya
11. Kzyl-Orda Canal
12. Syr Dar'ya Delta

At the end of 1980's, when the level dropped by about 13 m and reached about +40 m, the Aral Sea divided into the Large and Small Aral

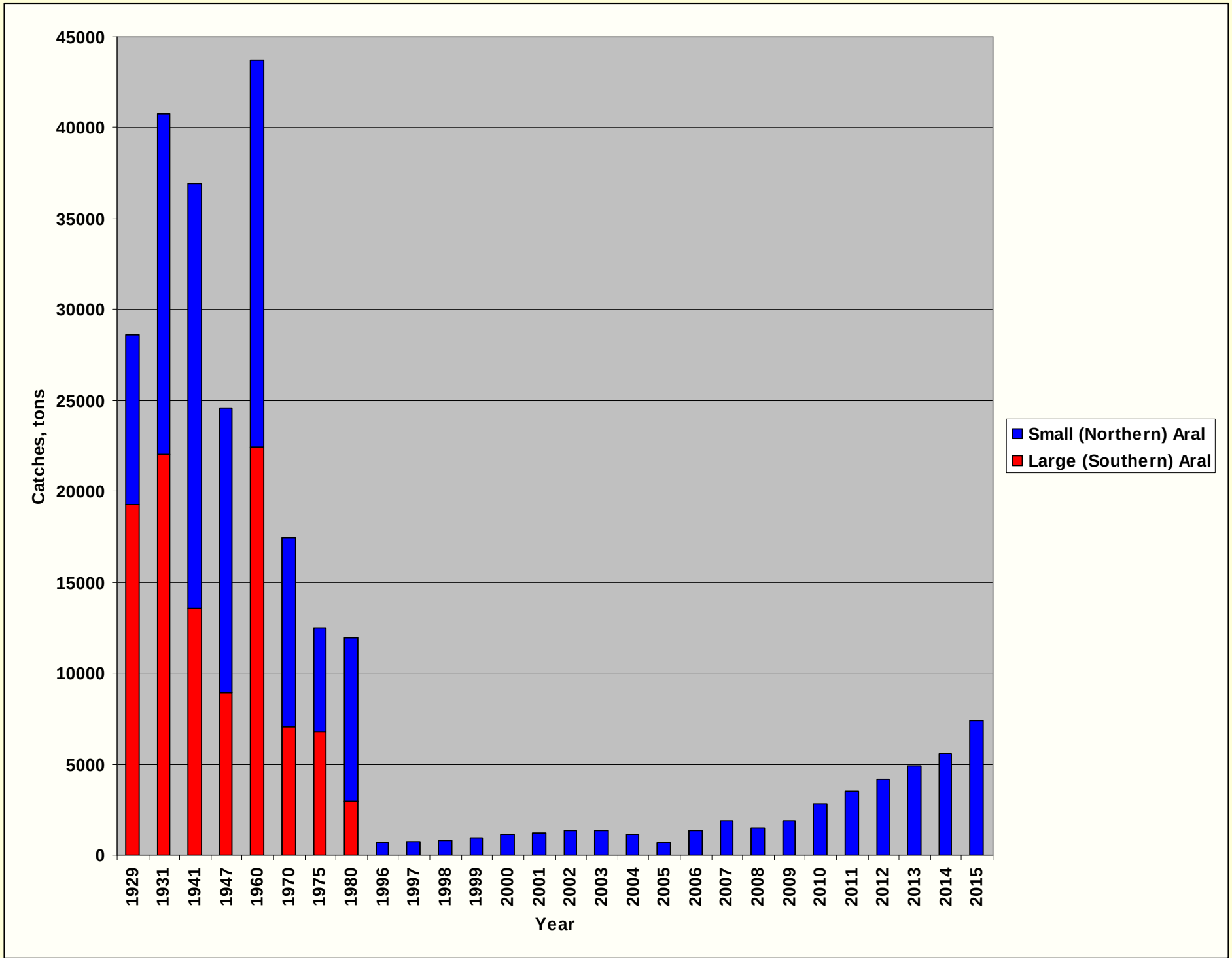
Area 40000 km^2 (60% from 1960)
Volume 333 km^3 (33% from 1960)
Salinity 30 g/l (10 g/l in 1960)

Between autumn 1987 – spring 1989 Aral Sea divided into 2 lakes: Small (Northern) Aral and Large (Southern) Aral. In both lakes salinity increased and in each lake practically the same number of free-living animals were able to survive.

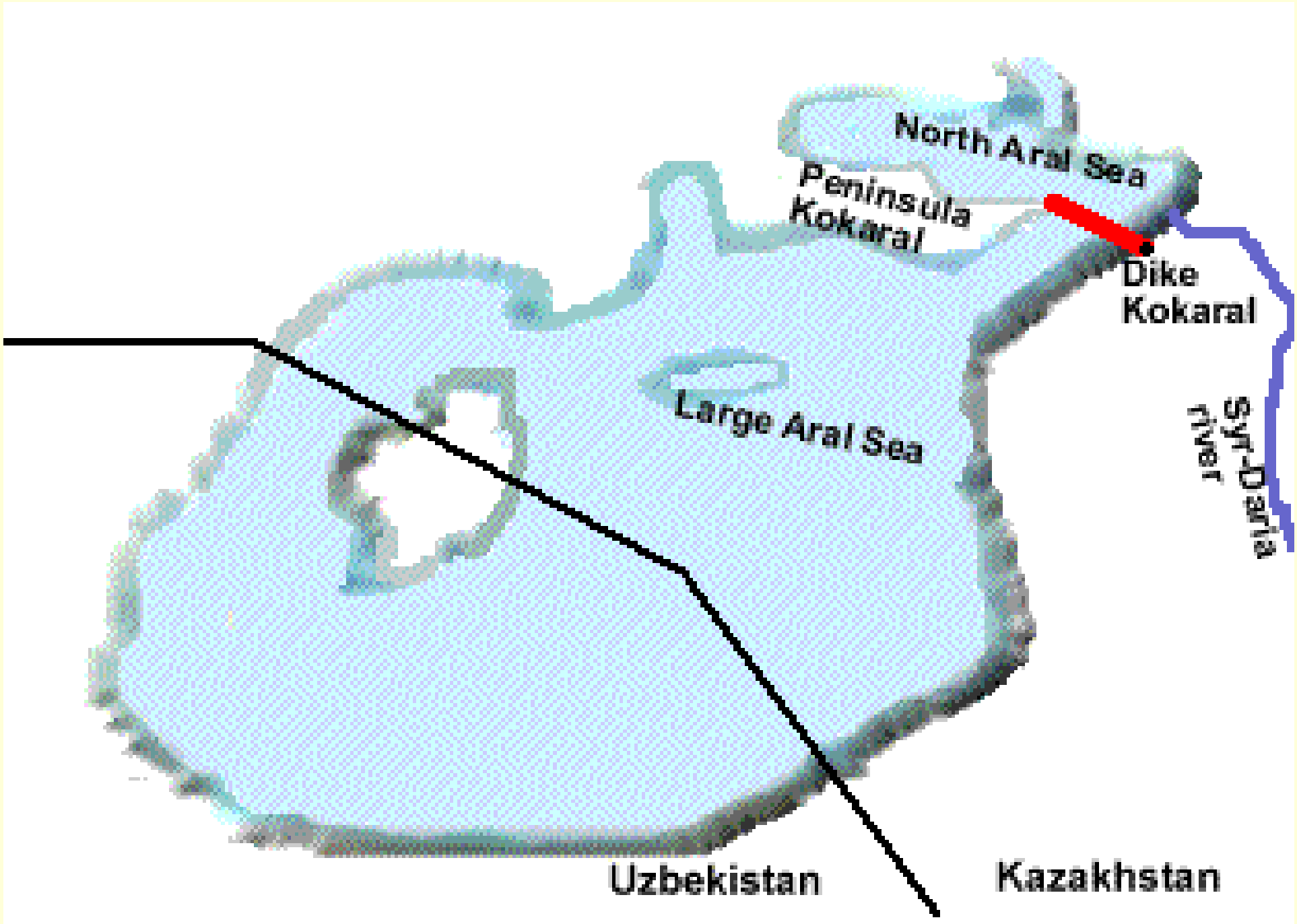

Aral Sea level and salinity
Level, m a.s.l
Salinity, g/l
Year
55.00
50.00
45.00
40.00
35.00
30.00
25.00
20.00
180.00
170.00
160.00
150.00
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
Salinity in the Large Aral continues to go up while in the Small Aral it has begun to go down after the Aral Sea division
Aral Sea level
Small Aral level
Large Aral level
Aral Sea salinity
SmallAral salinity
Large Aral salinity
W. Large Aral salinity
E. Large Aral salinity

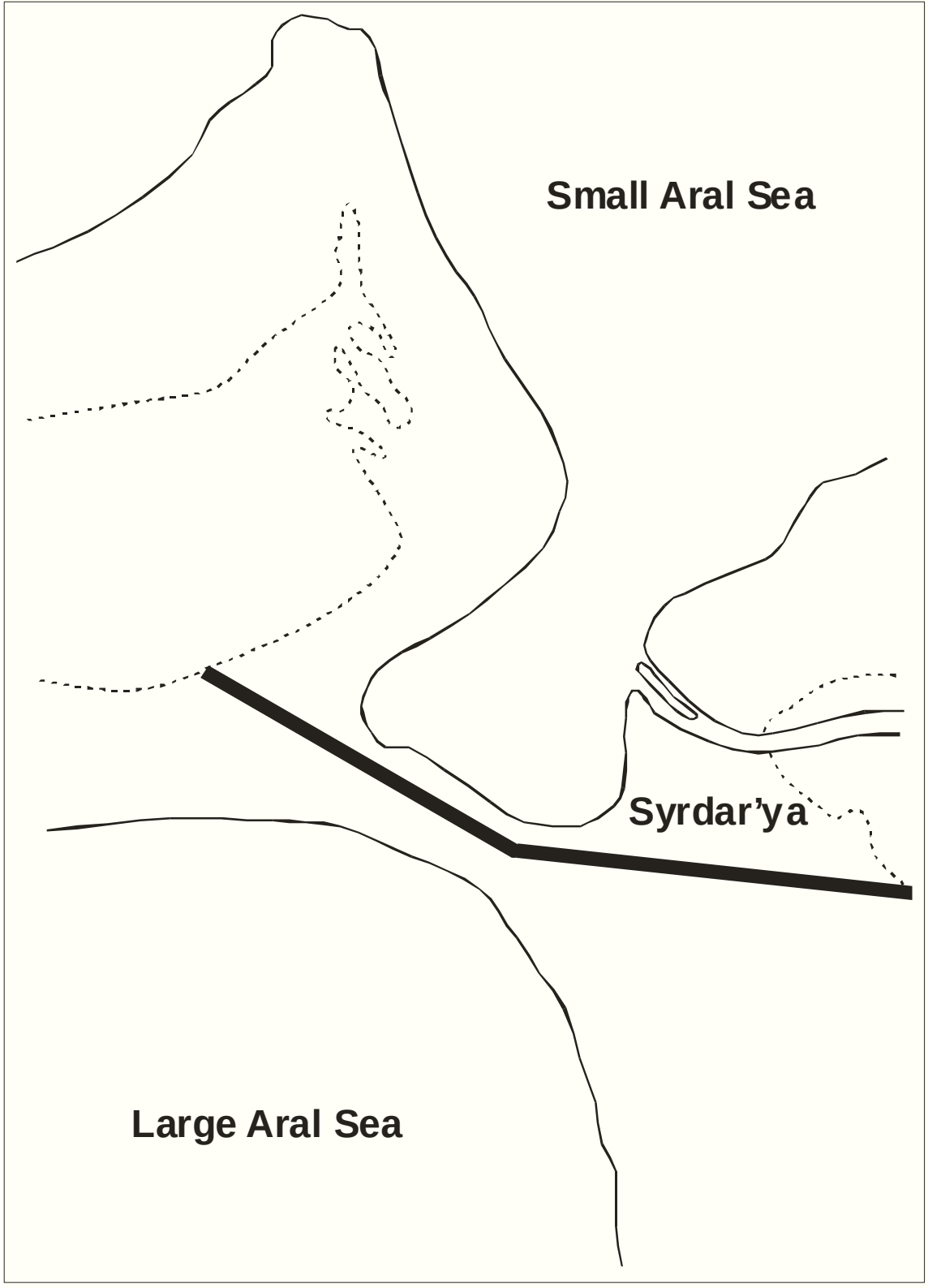
- The resulting rapid increase in salinity has caused a dramatic decrease in the lake biodiversity and biological resources and loss of a once thriving fishery.
- Only a small part of the indigenous biota has survived.

Dynamics of fish catches in the North and South Aral Sea



Dike in Berg strait is preserving Small (Northern) Aral and rehabilitating its biodiversity.



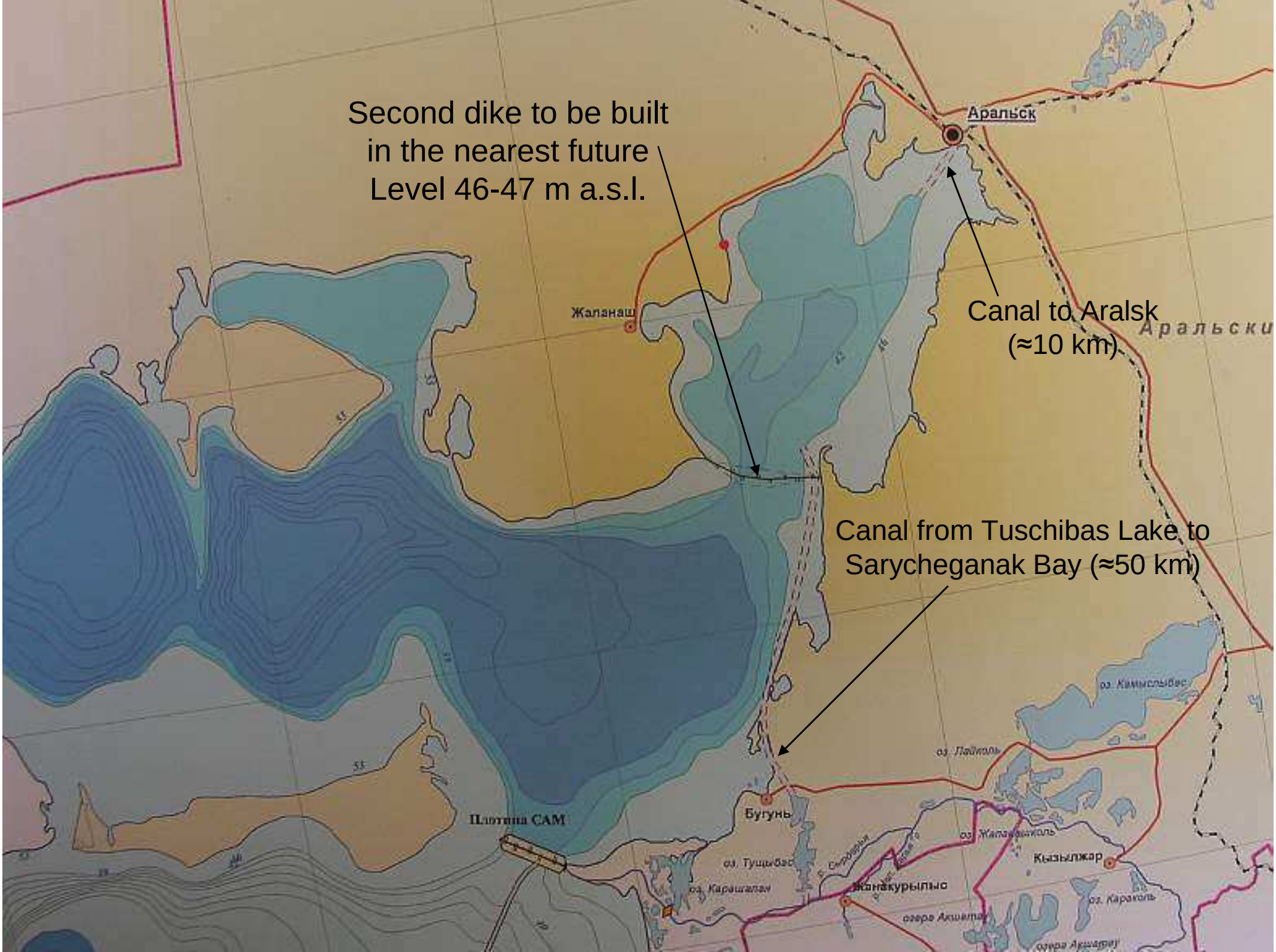


Dike in Berg strait is preserving Small (Northern) Aral and rehabilitating its biodiversity.

Source: Aladin N.V., Plotnikov I.S., Potts W.T.W., 1995. The Aral Sea desiccation and possible ways of rehabilitation and conservation of its North part // Int. J. Environmetrics. Vol. 6: 17-29.

New Kok-Aral dike built by Russian company “ZARUBEZHVODSTROY”

- The water level in the Small Aral has increased several meters and its salinity has returned to levels that can sustain the pre-1960 ecosystem.
- The biodiversity and biological resources also has been somewhat rehabilitated, and the commercial fisheries have revived.


Second dike to be built
in the nearest future
Level 46-47 m a.s.l.
Аральск
Canal to Aralsk
(≈10 km)
Жаланаш
Аральски
Canal from Tuschibas Lake to
Sarycheganak Bay (≈50 km)
Плотина САМ
Бугунь
оз. Тущыбас
оз. Карашалан
Жанакурылыс
Кызылжар
оз. Камыслыбас
оз. Лайкуль
оз. Жалаулыколь
оз. Караколь
озера Акшатау

1. Small Aral: level ~42 m, area 3300 km^2, salinity 6-7 g/l

2. Western Basin of Large Aral: level ~25 m, area 3120 km^2, salinity >150 g/l

3. Tsche-Bas Bay: level ~28 m, area 385 km^2, salinity 85 g/l

4. Central Aral: level 27-28 m, area 405 km^2, salinity variable

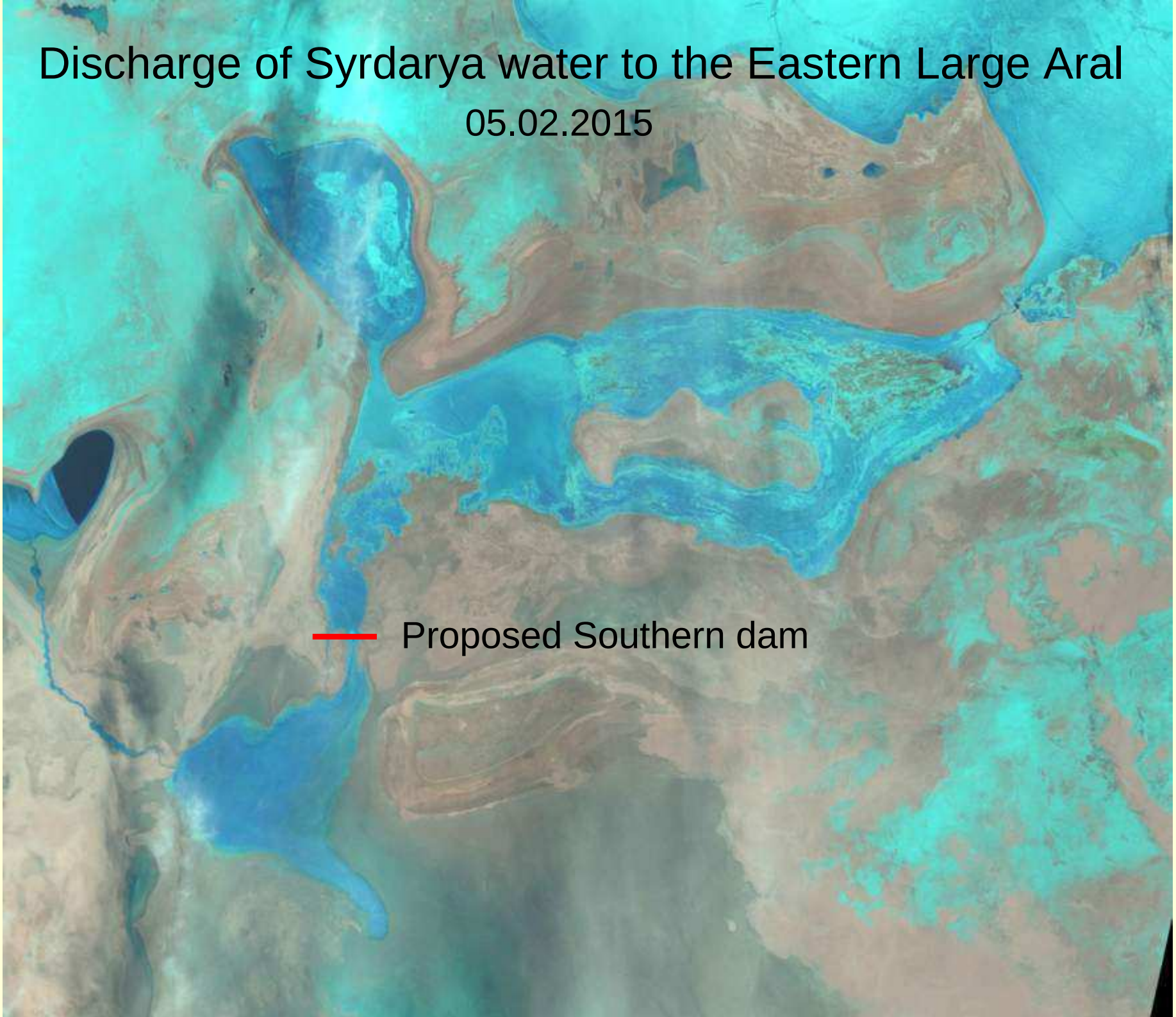
5. Eastern Basin of Large Aral: level 26-27 m, area 974 km^2, salinity >150 g/l?

TOTAL ARAL AREA = 8031 km^2

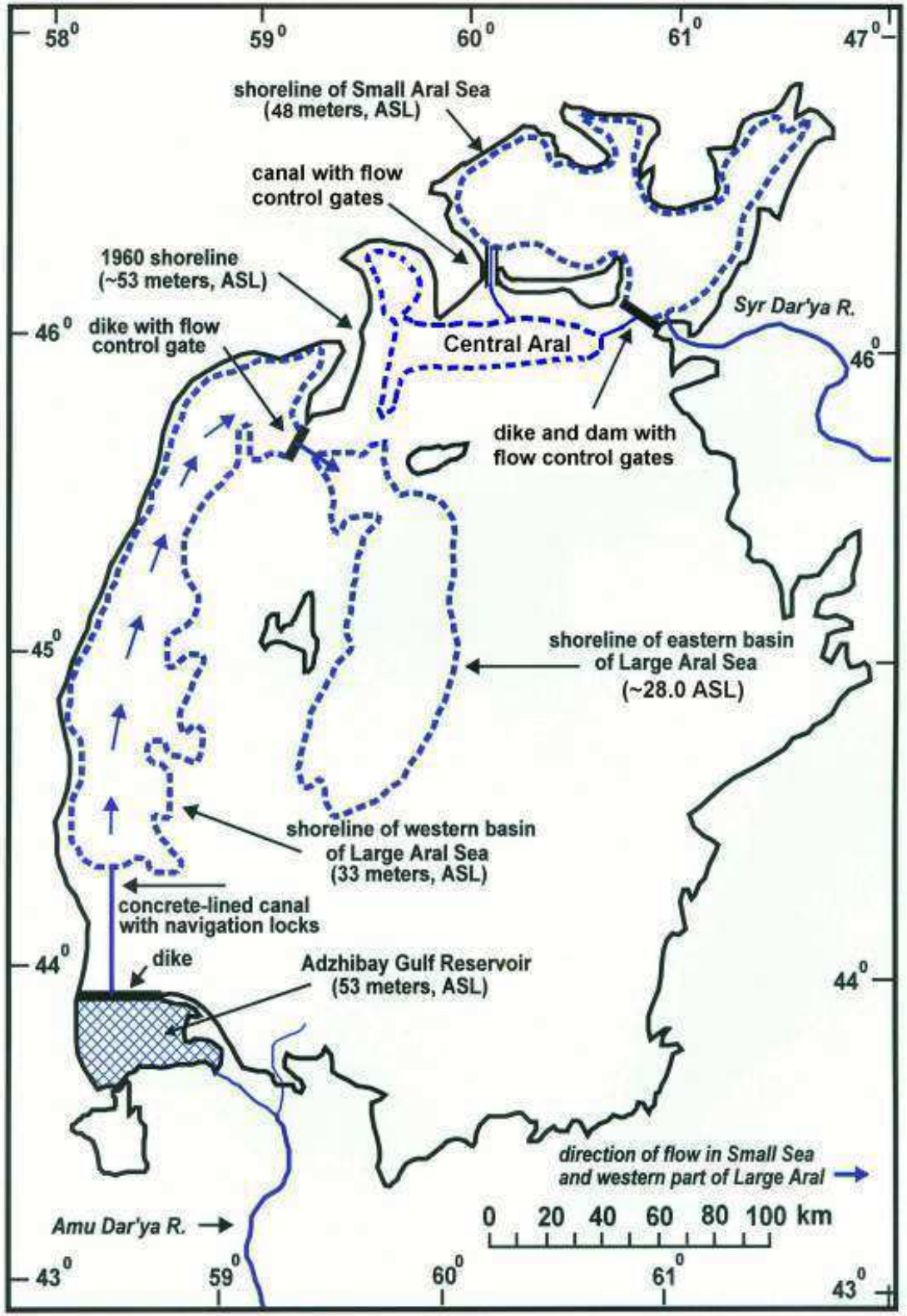
A – Kokaral dam (Central dam)

B – Proposed Northern dam

C – Proposed Southern dam


Discharge of Syrdarya water to the Eastern Large Aral
05.02.2015
Proposed Southern dam

- The remnants of the hyperhaline Southern (Large) Aral continue their retreat and salinization.
- The Large Aral contains no fish species, and almost all the invertebrate species have been lost.
- The only biological resource here in hyperhaline environment is brine shrimp (*Artemia*), and its eggs are harvested now.



Concept to Partially Preserve Small and Large Aral Seas (Lvovich and Tsigelnaya, updated and modified by P. Micklin)

Small Aral Sea: Level 48 m ASL, area 4830 km^2, vol. 53.5 km^3, river inflow 5.0 km^3, outflow toward L. Aral 1.0 km^3, salinity 6.0 g/l.

Large Aral Sea

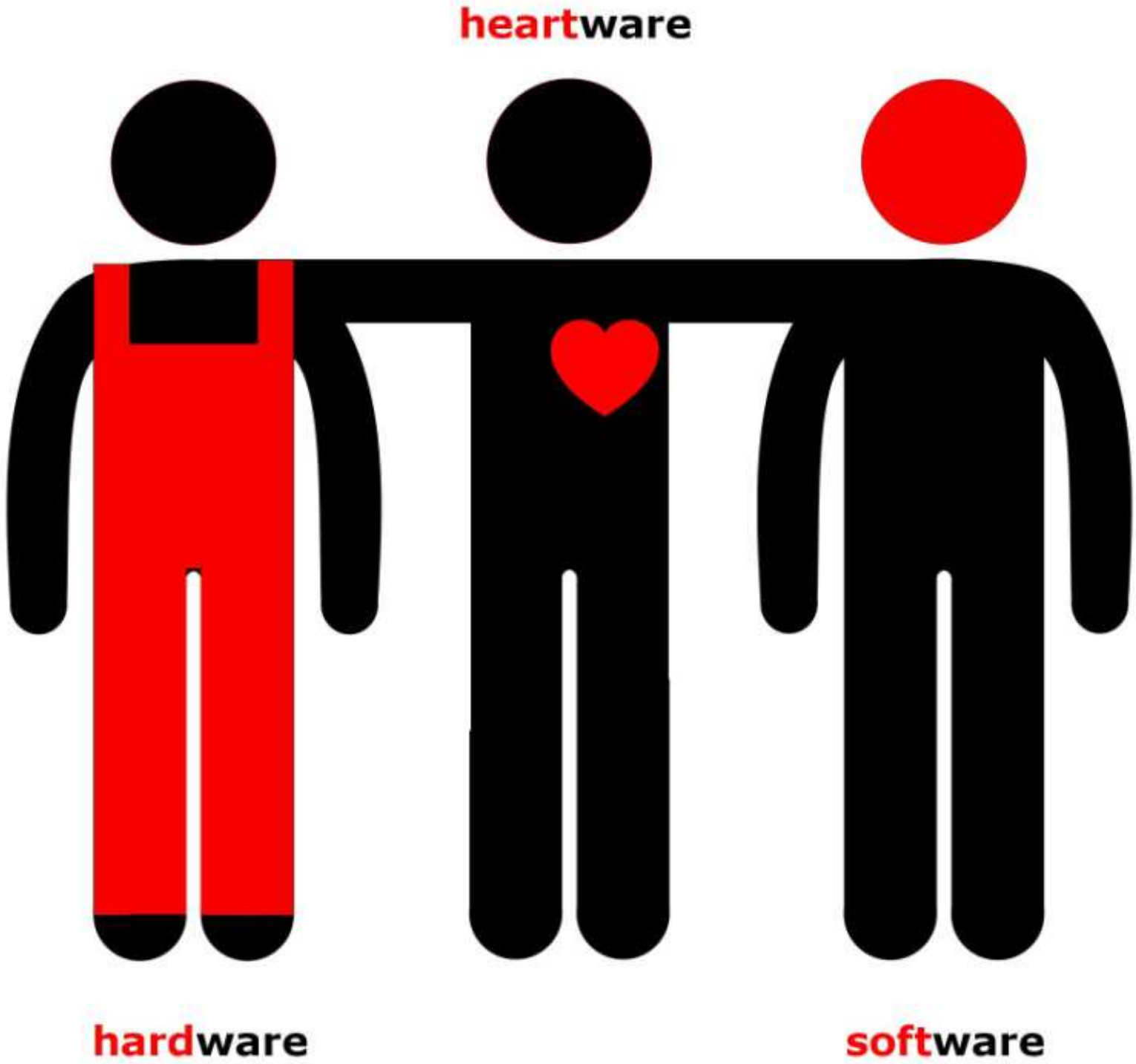
Western Sea: level 33 m ASL, area 6200 km^2, vol. 85 km^3, river inflow 6.4 km^3, net groundwater inflow 2.0 km^3, outflow to E. Aral 3.6 km^3, salinity drops to 42 g/l by 2060 and to 15 g/l by 2120.

Eastern Sea: level ~28.0 m ASL, Area ~3,800 km^2, vol. 7.6 km^3, inflow from W. Aral 3.6 km^3, inflow from Central Aral highly variable, salinity >200 g/l

Adzhibay Gulf Reservoir: level 53 m ASL, area 1147 km^2, vol. 6.43 km^3, inflow from Amu Dar'ya 8.0 km^3, outflow to Western Aral basin 6.6 km^3, salinity ~ 2 g/l


ABC
LAKES PROJECT
INTERNATIONAL EAEU PROJECT: ARAL, BALHASH, CASPIA

- In conclusion, the authors of this report argue that by setting complex and hard-to-reach scientific and practical goals, such as, for example, preserving the biological diversity and biological resources of the Caspian and Aral Seas, researchers need to rely not only on modern scientific equipment and computer programs, but they also must have heartware.
- The authors are sure that only men can try to restore what they themself have put at risk or destroyed. Unfortunately, robots will never be able to do this.
- Concluding our report, we demonstrate a symbolic drawing of infographics by Mikhail Olegovich Janson. The previously shown logo, dedicated to the study of the Aral Sea, Balkhash and the Caspian, was also made by him.


heartware
hardware
software

Thank you for your attention

Biological resources
of Caspian and Aral have future